Hibiscus diversifolius subsp. *rivularis* (Bremek. & Oberm.) Exell (Malvaceae) in Australia

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Summary

Badry, M.O., Crayn, D.M. & Tate, J.A. (2017). *Hibiscus diversifolius* subsp. *rivularis* (Bremek. & Oberm.) Exell (Malvaceae) in Australia. ***Austrobaileya* 10(1): 113–120**. *Hibiscus diversifolius* Jacq. is a widespread pantropical species found in Africa, Asia, Australia, and North and South America. In Australia, most populations are yellow-flowered, conforming to *H. diversifolius* subsp. *diversifolius*. However, a dark pink to maroon-flowered form previously recognized as a colour variant of subsp. *diversifolius* should be recognized as subsp. *rivularis*. After examining material from several herbaria, we find that *H. diversifolius* subsp. *rivularis* in Australia is restricted to the Atherton Tableland, north Queensland, and the remaining occurrences of the species along the east coast and in Western Australia are subsp. *diversifolius*. Outside Australia, subsp. *rivularis* is found in Africa and Brazil and the first Australian record dates to 1947. Based on this we suggest that its presence in Australia is a result of naturalisation due to one or more introductions from Africa via service personnel and/or equipment returning from the Middle East during and after World War II. A full description of *H. diversifolius* subsp. *rivularis* is provided, as are the key characters used to distinguish the two subspecies as they occur in Australia.

Key Words: Malvaceae, *Hibiscus*, *Hibiscus diversifolius* subsp. *rivularis*, Australia flora, Queensland flora, leaf cuticle surface, seed coat, naturalised status

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Introduction

Hibiscus Section *Furcaria* DC. is a diverse, but natural group, containing *c*. 109 taxa (Wilson 2006). In Australia, the most recent treatment of Sect. *Furcaria* recognized 32 species, 31 indigenous species (of which 29 are endemic) and one (*H. sabdariffa* L.) naturalised (Wilson & Craven 1995; Craven *et al*. 2003, 2016). Within Sect. *Furcaria*, *H. diversifolius* Jacq. appears to be the most widespread species, being found in Africa, Madagascar, Asia, Australia, the Pacific islands (including New Zealand), and North and South America (Wilson 1993; Badry *et al*. 2015), and contains two subspecies: yellow-flowered *H. diversifolius* subsp. *diversifolius* and purple-flowered *H. diversifolius* Jacq. subsp. *rivularis* (Bremek. & Oberm.) Exell. (Edmonds 1991; Wilson 1999).

In Australia, *H. diversifolius* occurs primarily on the east coast from Queensland to New South Wales, and in south-western Western Australia. Only the pantropical yellow-flowered *H. diversifolius* subsp. *diversifolius* has been recognized as occurring in Australia (Wilson 1974, 1993). However, there has been some uncertainty regarding the validity of the dark pink to maroon-flowered form of *H. diversifolius* in Australia. Although it was recognized as occurring on the Atherton Tableland, in north Queensland, it was not referred to the *H. diversifolius* subsp. *rivularis* of Africa and Brazil, and was therefore regarded as a colour variant of subsp. *diversifolius* (Wilson 1994, 2006; Wilson & Craven 1995). After examining several herbarium specimens of the purple-flowered form and comparing them to specimens of *H. diversifolius* subsp. *diversifolius*, we determined that the plants previously collected from the Atherton

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Tableland are morphologically distinct from subsp. *diversifolius* and can be accommodated within *H. diversifolius* subsp. *rivularis.*

The objective of this paper is to provide a description of *Hibiscus diversifolius* subsp. *rivularis* from Queensland so that it can be formally recognised for Australia and to provide distinguishing morphological characteristics to separate the two subspecies of *H. diversifolius* in Australia.

Materials and methods

Herbarium specimens from BRI, CANB, CBG, CNS, MPN, NSW and PERTH (herbarium acronyms as per Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff 2016) were examined, together with field collections. The measurements for floral parts were based on material reconstituted with hot water, while other plant parts were measured from dried materials using a stereomicroscope (SM) Olympus SZ×7 with an Olympus SC100 digital camera (Olympus America Inc., USA) at the Dame Ella Campbell Herbarium (MPN), Massey University, New Zealand. Leaf surface patterns, stomata, and the seed coat were also studied by scanning electron microscopy (SEM). Samples of dry leaves and mature seeds were mounted onto clean stubs using double-sided adhesive tape, coated with gold using a BAL-TEC SCD 050 ion sputtering device, and examined and photographed using a FEI Quanta 200 Environmental Scanning Electron Microscope (at an accelerating voltage of 20 kV) at the Manawatu Microscopy and Imaging Centre (MMIC), Massey University, New Zealand.

Taxonomy

Hibiscus diversifolius subsp. **rivularis** (Bremek. & Oberm.) Exell., *Fl. Zambesiaca* 1(2): 444 (1961); *H. rivularis* Bremek. & Oberm., *Ann. Transvaal Mus.* 16: 424 (1935). **Type:** Botswana: Chobe River Kabulabula, Bechuanaland Port., July 1930, *Van Son s.n.* (holo: PRE 28936 *n.v.*; iso: BM).

Perennial shrub much-branched from the base, 1.5–3 (4) m high. **Stems** terete, erect, branched, stout, and woody at the base, prominently aculeate at the plant base, with or without lines of pubescence, the stems above aculeate, with dense and fine simple and stellate trichomes. **Stipules** linear, 3.3–10 mm long, caducous, pubescent (simple trichomes). **Leaves** heteroblastic, alternate, petiolate. **Petioles** 0.3–11.2 cm long with dense simple, bifurcate and stellate trichomes on the adaxial side, 1–2 lines of fine to stout sharp conical prickles on the abaxial side. **Lamina** 1.6–12.5 cm × 0.4–14.4 cm, with simple and bifurcate trichomes on the adaxial surface and simple, bifurcate and stellate trichomes on the abaxial surface, with different forms: lower leaves near base of the plant with laminae broadly ovate, entire to shallowly-palmately 3–5-lobed, base rounded to truncate, margins ± dentate to crenate, apex acute or obtuse; at the mid-plant, laminae broadly ovate, triangular, or suborbicular, shallowly-palmately 3–5-lobed, base cordate, rounded or truncate, margins dentate or irregularly serrate, apex acute or acuminate; upper leaves with laminae lanceolate, ovate or elliptic, base cuneate or truncate, margins finely to coarsely dentate, apex acuminate or acute; uppermost leaves on flowering branches very reduced into narrowly elliptic bracts with finely dentate margins, base cuneate. **Foliar nectary** 1.2–3.3 mm long, conspicuous, narrowly elliptic, on the base of the midrib on the abaxial surface. **Flowers** 8–9 cm diameter, in terminal racemes, subsessile, pedunculate. **Peduncle** short, 1.4–3.2 mm long, densely stellate-pubescent. **Pedicel** 1.4–4.2 mm long, the indumentum dissimilar to that of the peduncle (densely hispid, with long simple trichomes mixed with fine conical prickles). **Epicalyx** segments 8–10, subulate, 4.5–14.5 mm long, slightly connate at the calyx base, hispid. **Calyx** 11.8–20.4 mm long, densely covered with long stiff bristles, lobes 7.5–15.2 mm × 4.3–8.5 mm, narrowly triangular or lanceolate, apex acute, having a prominent thickened midrib and two thickened marginal ribs; calyx nectary ± conspicuous, narrowly elliptic, 0.9–1.9 mm long on the midrib. **Corolla** of five petals 37.1–57.7 mm × 21.4–37.8 mm, shortly connate at the base, obovate, dark pink to maroon, deep maroon



Fig. 1. ***Hibiscus diversifolius*** subsp. ***rivularis*.** Fertile cultivated specimen (*Whitten s.n.*, BRI [AQ45592]). Photo: P. Joshi.



Fig. 2. ***Hibiscus diversifolius*** subsp. ***rivularis*****.** A. vegetative part of the plant with a close-up view of an open flower. B. flower and buds viewed from side with floral parts as indicated. C. view of an open fruit showing the seeds. D. enlarged epicalyx segment. A–C from *Jago 7798* (CNS); D from *Crayn 1384 & Gagul* (MPN). Photos A–C: R.L. Jago, D: M.O. Badry.

in the center, pubescent with flagellate non-glandular trichomes, apex rounded to retuse; claw margins ciliate, with dense unicellular trichomes. **Stamens** numerous, staminal tube 16.4–19.1 mm long, dark red-purple, adnate to the petals at the base, with thin-walled simple trichomes at the connection point between the petals and the staminal tube, otherwise glabrous; filaments 1.4–2.7 mm long. **Styles** five, basally connate and free at the tip, exserted beyond the staminal tube. **Ovary** syncarpous, superior, 5-locular, ovules 2 or more per locule. **Capsules** 11.2–22.8 mm long × 9.5–18.3 mm diameter, ovoid, acute, pointed, covered with dense, long, stiff appressed trichomes. **Seeds** ovoid-reniform in outline, 3.7–4.3 mm × 2.6–3.2 mm, dark brown, double reticulate, puberulent, hilum glabrous (**Figs. 1–3**).

Additional selected specimens examined **(*H. diversifolius*** subsp. ***rivularis*****): Australia. Queensland.** Cook District: Lake Barrine, Eacham, Jan 1947, *Flecker CAIRNS 10554* (CNS); Lake Barrine, Atherton Tableland, Sep 1997, *Cooper & Cooper 1154* (CNS); Scenic Reserve 440, Lake Euramoo, Atherton Tableland, Aug 1967, *Brass 33650* (CNS); *ibid*., Jul 1970, *Kershaw & James ANU10025* (CANB); *ibid*., Aug 1970, *Kershaw s.n.* (CNS 32809, 32810.2); *ibid*., Jul 1992, *Gray 5443* (CNS); Toohey Creek, near Gadgarra, Atherton Tableland, Mar 1995, *Jensen 162* (CNS); Euramoo Swamp, swamp edge next to pump shed below lookout, Nov 2015, *Crayn 1384 & Gagul* (MPN). Moreton District: cult. Mt Coot-tha Botanic Gardens O24/25, Oct 1984, *Witten s.n.* (BRI [AQ455292]).

Selected specimens examined **(*H. diversifolius*** subsp. ***diversifolius*****): Egypt.** Qena Governorate: El Mahroosa, Kream Island, Nakada, 271 km from Aswan Reservoir and 20.2 km S of Qena City, Dec 2010, *Badry s.n.* (South Valley University Herbarium). Dandara: El Jebbail, Dandara Island, Dec 2013/May

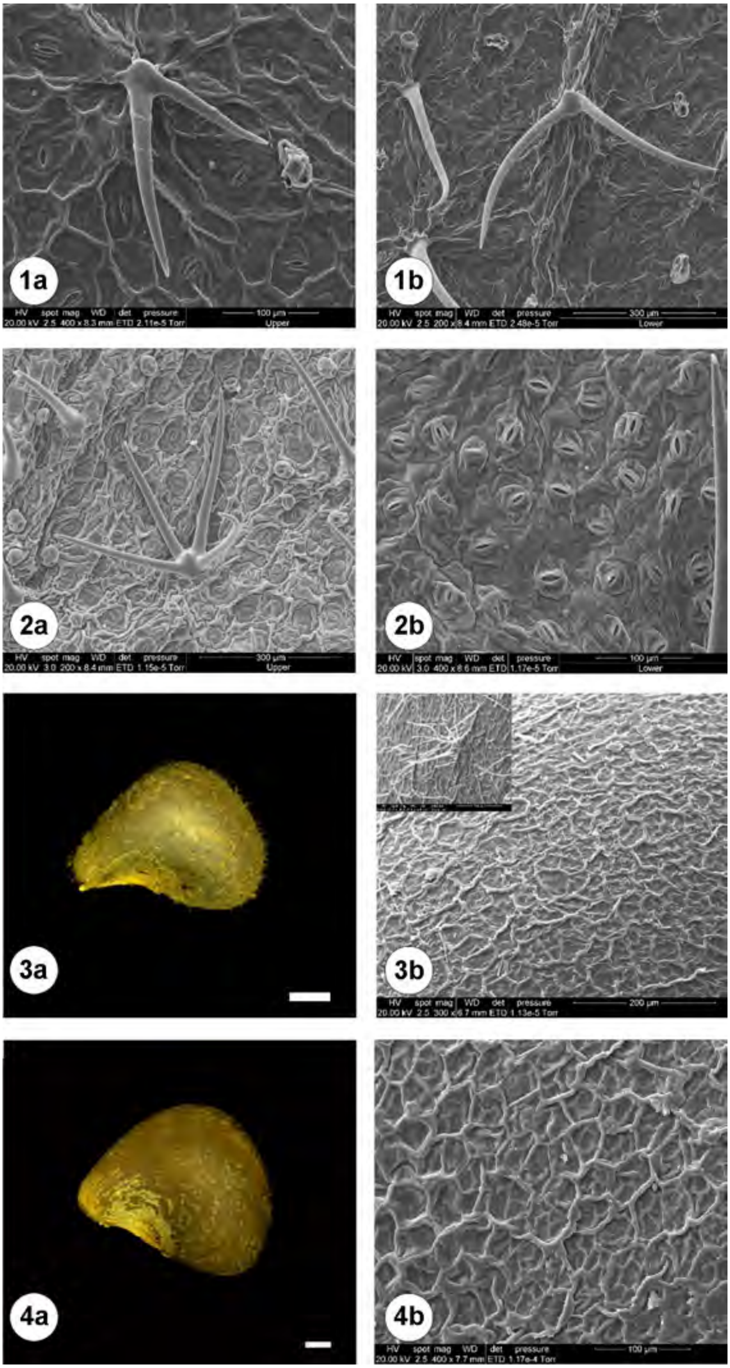


Fig. 3. Comparison of leaf and seed microfeatures for ***Hibiscus diversifolius*** subsp. ***rivularis*** (1, 3) and subsp. ***diversifolius*** (2, 4). (1, 2) SEM micrographs of leaf surface patterns (a: adaxial surface, b: abaxial surface); (3, 4) Seed micrographs (a: SEM of seed shape outline, b: SEM of seed coat sculpture). 1 & 3 from *Crayn 1384 & Gagul* (MPN); 2 & 4 from *Lepschi & Lally 2569* (CANB).

2014, *Badry s.n.* (MPN 49882, South Valley University Herbarium). **Papua New Guinea.** Gulf Province: Near Malalaua, Mar 1966, *Craven 930* (CANB). **Australia. Western Australia.** Avon District: Junction of Victor Road & Glen Road, Darlington, Perth, Feb 1996, *Lepschi & Lally 2505* (PERTH); Nyaania Brook, S end of Newman Road, Darlington, Perth, Apr 1996, *Lepschi & Lally 2569* (PERTH); In bed of Nyaania Creek, corner of Glen & Victor Roads, Darlington, Jan 1997, *Hussey s.n.* (PERTH 4609115). Darling District: Bank of Swan River at Maylands, Nov 1996, *Elliott s.n.* (PERTH 2246724); Swan River foreshore, N of St Anne's Hospital, Maylands, Dec 1983, *Keighery 6367* (PERTH); Swan River near junction of Abernethy Road & Great Eastern Highway, Belmont, Perth, Oct 1995, *Lepschi & Lally 2100* (PERTH); *ibid*., Jan 1996, *Lepschi 2483* (PERTH); Drain between Melville Bowling Club and Swan River, Applecross, Feb 1997, *Brims 317* (PERTH); Swan River, Maylands, Nov 2009, *Thiele 3939* (PERTH). **Queensland.** Wide Bay District: Great Sandy NP, Fraser Island, Ocean Lake, Southern End, 4 km NW of Orchid Beach, Nov 2002, *Forster PIF29057* (BRI); Great Sandy NP, Fraser Island, northern side of Wathumba Swamp, 6.5 km WNW of Orchid Beach, Sep 2004, *Forster PIF30262* & *Leiper* (BRI); Ocean Park Estate, Dundowran, Nov 1991, *Forster PIF9187* (BRI). Moreton District: End of Wallaby Way, Pimpama, May 2003, *Bean 20425* (BRI); Roadside at Jacobs Well Area, Sep 1976, *Elsol* & *Dowling 39* (BRI); Sunscape Drive, Eagleby, Aug 2003, *Bean 20669* (BRI); North Stradbroke Island, 18 Mile Swamp, Sep 2001, *Stephens 34 & Daniel* (BRI); *ibid*., Oct 2001, *Stephens & Daniel* (BRI). **New South Wales.** North Coast District: 0.7 km S of Broadwater on Pacific Highway, Nov 2005, *Johnstone 1607* (CANB).

***Distribution and habitat*:** In Australia *Hibiscus diversifolius* subsp. *rivularis* is a long-lived perennial of moist habitats, found on the margins of freshwater bodies on the Atherton Tableland, north Queensland in plant communities typically dominated by *Phragmites* species (Poaceae).

Hibiscus diversifolius subsp. *rivularis* is usually confined to tropical Africa where it is known from the Democratic Republic of Congo, Angola, Tanzania, Uganda, Burundi, Rwanda, Malawi, Zambia, Zimbabwe, Mozambique, Namibia's Caprivi Strip and Botswana (Bechuanaland Protectorate). It is also recorded from Brazil (Wilson 1999; Esteves *et al*. 2014).

***Notes*:** The two subspecies of *Hibiscus diversifolius* may be distinguished in Australia at the vegetative, flowering and fruiting stages (**Table 1**). In Africa it is easy to distinguish between the subspecies of *H. diversifolius* where the yellow-flowered *H. diversifolius* subsp. *diversifolius* is also distinctive by the longitudinal line or lines of pubescence on its stems. This distinction, however, does not apply to the Australian material, especially at the vegetative stage, because uniformly pubescent stems occur on both yellow- and maroon-flowered specimens. The use of leaf micro-morphology along with seed coat sculpturing provides new significant characters that help to distinguish the subspecies in Australia **(Table 1, Fig. 3)**.

In 1943 the headquarters of the Australian Army in north Queensland was transferred from Townsville to the Atherton Tableland. Further developments saw the facilities become a major rehabilitation area and jungle warfare training ground for troops of the 6th, 7th and 9th Australian Divisions returning from service in North Africa during World War II (Pearce 2009). The oldest known herbarium specimen examined in this study was collected in 1947 from Lake Eacham. Thus, it seems possible that the subspecies was introduced from Africa via service personnel and/or equipment returning from the Middle East and that the species then became established and naturalised in the area.

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Table 1. Distinguishing morphological characters of the two subspecies of *H. diversifolius* in Australia

Character		*H. diversifolius* subsp. *rivularis*	*H. diversifolius* subsp. *diversifolius*
Leaf shape			
Mid-stem leaves		Shallowly palmately 3–5-lobed	± deeply-palmately 3–5-lobed
Uppermost leaves		Narrowly-elliptic bracts	Reduced to narrowly-lanceolate or linear bracts
Leaf cuticle surface			
Adaxial surface	Cuticular surface	Reticulate, relief of cell wall boundaries ± striated. (**Fig. 3: 1a**)	Ruminate, relief of cell wall boundaries striated. (**Fig. 3: 2a**)
Abaxial surface	Stomata orientation	Same level as epidermal cells	Raised above the epidermal surface
	Cuticular surface	Ruminate, relief of cell wall boundaries smooth (**Fig. 3: 1b**).	Ruminate, relief of cell wall boundaries striated (**Fig. 3: 2b**)
Petal colour		Dark pink to maroon, deep maroon in the center (**Fig. 2A**)	Lemon-yellow, with a dark purplish basal blotch
Seed vestiture		Puberulent (**Fig. 3: 3a, b**)	Glabrous (**Fig. 3: 4a, b**)
Seed surface patterns			
Anticlinal cell walls		Boundaries raised-channeled, straight to slightly sinuous and thick with ruptured ridges	Boundaries raised, straight to slightly sinuous and thick with definite ridges
Periclinal cell walls		Thick, flat and channeled (**Fig. 3: 3b**)	Thick, flat to slightly concave (**Fig. 3: 4b**)

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